

TEMPORAL AND SPATIAL VARIATION OF PARASITISM IN *DANAUS PLEXIPPUS* (L.) (LEPIDOPTERA: NYMPHALIDAE: DANAINAE)

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Abstract

The incidence of parasitism of *Danaus plexippus* (L.) larvae was studied over a one year period. The only parasite reared out of instar III and older larvae was the tachinid *Sturmia convergens* (Wied.). Levels of parasitism ranged from 11% to 100%. Time of year and the size of the food plant patch strongly influenced levels of parasitism, being lowest in winter and in larvae found on isolated plants.

Introduction

The population dynamics of any species of animal is intimately associated with the density and dispersion of suitable resources. This is especially the case for the larvae of many Lepidoptera which utilise ephemeral or annual food plants. Interactions between the spatial dispersion of the plants and an insect's behaviour and physiological state will determine how many eggs are laid. Similarly, predators and parasitoids of these eggs and the resulting larvae will be influenced by the dispersion of the food plant and of the quarry itself.

In this paper, I attempt to answer two questions: (1) what is the temporal variation in mortality of *Danaus plexippus* (L.) larvae due to parasitoids; and (2) what are the effects of patch size and dispersion of host plants on the levels of parasitism.

The role parasitoids play in the regulation of the levels of butterfly populations is not fully understood (Gilbert and Singer, 1975). Considerable geographical and temporal variation in levels of parasitism have been recorded among field populations of larvae (e.g. Richards, 1940; Dempster, 1967, 1971 for *Pieris rapae*; Urquhart, 1960 for *D. plexippus*; Edmunds, 1976 for *D. chrysippus*). The proportion of parasitism does not always correlate with population trends (Duffey, 1968) although parasitoids have been viewed as important controlling agents in other studies (e.g. Parker and Pinnell, 1972; Varley *et al.*, 1973). Edmunds (1976) has also suggested that the levels of abundance of cryptic, palatable larvae are controlled by predators, whereas those of conspicuous aposematic caterpillars such as those of *D. plexippus* have high mortalities due to parasitoids.

Most studies of populations (and of parasitism) have been confined to pest/crop systems and a good deal of 'text-book ecology' comes from such studies. The monarch/milkweed system provides an opportunity to study host-parasite interactions under non pest/crop conditions. Milkweeds as a resource have a patchy distribution (Zalucki, Chandica and Kitching, in preparation). The influence of patch size and dispersion on parasitism is of interest, particularly in the light of recent theoretical studies of the effects of patchiness on predator-prey and host-parasite interactions (e.g. Hassell and May, 1974; May, 1978).

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Methods

Between June 1978 and September 1979 seven collections of *D. plexippus* larvae were made from *Asclepias* spp. plants in the Beenleigh and other areas of south-east Queensland (27°43'S; 153°12'E). On each occasion 20-30 plants were thoroughly searched and all larvae removed. These were reared in the laboratory to determine the type and percentage of parasitism. On three occasions larvae were collected from within large milkweed patches and from small isolated clumps (two to five plants within a metre of one another) and single isolated plants. A plant (or clump) was "isolated" if there was no other plant within 50 m. All other collections came from plants within patches. Larvae collected were separated into instars and kept together as a group, being placed into individual perspex tubes upon reaching the fifth instar. The dipterous parasitoids which emerged were kindly identified by Dr D. H. Colless, Division of Entomology, CSIRO, Canberra.

An index of the larval abundance of *D. plexippus* could not be obtained from the samples collected to determine parasitism as variable numbers of plants were searched and these were located in many different positions. An estimate of larval abundance was provided by counts of eggs and larvae on a planted-out patch of sixteen plants. Absolute counts of eggs and larvae were made on this patch (Zalucki, 1980). The monthly egg counts provide a reasonable index of the abundance of *D. plexippus* indicating trends in population changes over a one year period.

Results

Table 1 lists the collection areas, dates and numbers of each instar collected. All parasitoids reared out of the collected *D. plexippus* larvae were *Sturmia convergens* (Wied.) (Tachinidae). Table 2 summarises the percent parasitism by instar for all collections. No first or second instar larvae contained parasites. Larvae that become parasitised during the third instar

TABLE 1
Collection dates, sites, patch types and numbers collected in each instar

Date	Site	Patch type*	Nos collected in each instar				
			I	II	III	IV	V
21.vi.78	Beenleigh	P	8	3	2	3	6
11.x.78	Logan Village	P	29	7	11	5	3
13.xii.78	Beenleigh	P	9	3	7	1	7
13.xii.78	Beenleigh	S	18	11	9	1	3
20.ii.79	Beenleigh	P	—	—	2	4	5
20.ii.79	Beenleigh	S	—	—	3	2	—
15.v.79	Beenleigh	P	—	—	4	7	10
15.v.79	Beenleigh	S	—	—	2	4	4
15.vii.79	Nathan	P	—	—	1	4	5
15.ix.79	Sunnybank	P	—	—	10	6	8

* P = large milkweed patch, diameter >20 m.

S = single milkweed plants or small clump >50 m from nearest other milkweed.

TABLE 2
Incidence of parasitism by *Sturmia convergens* in larvae of different instars*

Instar	Number parasitised	Number not parasitised	Death (other causes)	% parasitised
I	0	49	15	0
II	0	24	9	0
III	16	28	8	36.4
IV	22	12	3	64.7
V	40	7	4	85.1

* Includes both patch and single plant collections.

will usually pupate normally. The parasitoid larvae will then bore out of the pupa, killing it, fall to the ground and themselves pupate. The adult fly emerges one to two weeks later depending on temperature. Occasionally, the parasitoid will burrow out of instar V. Usually one parasitoid emerged per host though on occasions from two to four larvae emerged from a single host. If a third or older instar died it was dissected and checked for parasitoid larvae. If one was found, the *D. plexippus* larvae was scored as parasitised, otherwise such larvae were excluded from the calculation of the figures for percentage parasitism presented in Tables 2 and 3 and Figure 1. As only instars III, IV and V are parasitised the percent parasitism for each sampling occasion is based on these larvae only (Fig. 1, Table 3).

Figure 1 shows the incidence of parasitism over time and patch size. The curve of the population index does not correspond to the dates of collection of parasitoids and offers only an indication of larval population changes over a year. Although based on a small number of larvae on each collection date (Table 3), there is a trend in the incidence of parasitism over the year. From low levels at the end of winter, the incidence of parasitism increases to a peak around the end of summer (Fig. 1).

Assuming that *D. plexippus* shows similar patterns of abundance in successive years, these levels of parasitism are closely associated with the abundance of larvae (Fig. 1). It is, however, unclear whether the decline in *D. plexippus* abundance is due to high parasitism by *Sturmia convergens*, or if *D. plexippus* declines for some other reason such as weather and the abundance of *Sturmia* declines in consequence.

TABLE 3
Estimated mortality of *D. plexippus* larvae from *Sturmia convergens* parasitoids

Month (1978)	% parasitism by <i>S. convergens</i> P ⁺	S ⁺⁺	Population index [†]
June	82 (11)*		
July			
August			
September			
October	11 (19)		7
November			32
December	67 (15)	38 (13)	27
January			37
February	64 (11)	20 (5)	71
March			153
April			118
May	100 (21)	50 (10)	39
June			20
July	80 (10)		39
August			28
September	42 (24)		39

* Figures in parenthesis show numbers of III, IV & V instar larvae collected which did not die of other causes, i.e. of 11 larvae collected in June 1978, 82% were parasitised.

† Egg counts from a cultivated milkweed patch between October 1977 and September 1978. Values refer to total numbers of eggs laid per month.

+ P = large milkweed patch >20 m diameter

++ S = single milkweed plants or small clumps >50 m from nearest other milkweed.

The effects of patch size and position are also shown in Fig. 1. Larvae on single or small isolated clumps are significantly less parasitised than larvae from 'large' patches during the same period of time. The percent parasitism of larvae in patches [$77\% \pm 20$ (SD), $N = 3$] and for "single" plants [$36\% \pm 15$ (SD), $N = 3$] based on those months when collections were made in each, were significantly different ($t = 2.3247$, $p < 0.05$).

Discussion

Caution must be exercised in the interpretation of figures for percentage parasitism in field populations when these are estimated by rearing samples of larvae. This is particularly the case if parasitised larvae and pupae are preyed upon selectively by small mammals (Campbell and Sloan, 1977). There is no evidence that mammal or bird predation is a major mortality factor in *D. plexippus*. Both larvae and pupae contain cardiac glycosides (e.g. Dixon *et al.*, 1978) which are vertebrate toxins and, supposedly, confer some immunity to such predation. My own studies on mortality in *D. plexippus* larvae (Zalucki, 1980) indicate that heavy losses due mainly to entomophagous invertebrates occur in the egg, first and second instars. Proportionately fewer larvae are lost in instars III, IV and V. Due to sampling difficulties losses in the pupal stage could not be estimated. Again vertebrate predation may be discounted. The percentage of parasitism in reared field samples will reflect, therefore, actual levels of parasitism in the field.

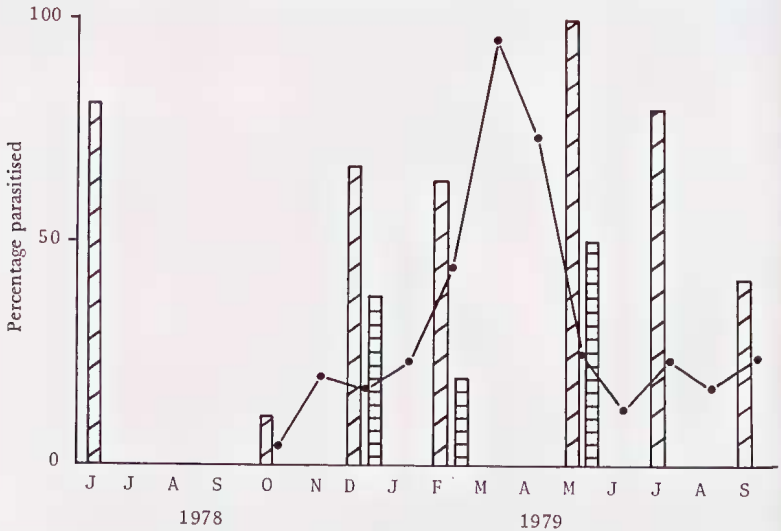


Fig. 1. Percentage parasitism of *D. plexippus* larvae by *S. convergens* over time. Cross hatching refers to larvae in large milkweed patches >20 m diameter, horizontal hatching to larvae on single plants or small clumps >50 m from nearest other milkweed. Population index (---) represents egg counts from a cultivated milkweed patch of 16 plants from October 1977 to September 1979 and indicates population trends only (refer to Table 3 for actual numbers of eggs).

The results for *D. plexippus* agree with Edmunds' (1976) hypothesis (see above). Larvae of *D. plexippus* are cryptically coloured and patterned when viewed from a distance on their host plant, but are brightly, aposematically coloured when viewed close-up. Levels of parasitism in *D. plexippus* larvae (instars III, IV, V) are high, as expected (up to 100%), although losses are also high in the egg and the first and second larval instars due to invertebrate predators from which cardiac glycosides provide no protection.

Changes in levels of parasitism over time show a seasonal trend which seems to correspond to changes in larval abundance of *D. plexippus*. Only long term observations on larval numbers and levels of parasitism will show whether or not the two cycle together and, accordingly, whether parasites are an important factor in population regulation. *Sturmia convergens* has also been recorded as a parasite of the common nymphalid, *Precis villida* (Fab.) and two moths, *Brithys crini* (Fab.) (Noctuidae) and *Agrius convolvuli* (L.) (Sphingidae) (Crosskey, 1973). No doubt there are other hosts. The varying abundance of these alternative hosts will influence the abundance of *S. convergens* and hence levels of parasitism in *D. plexippus*.

The patchy distribution of milkweeds will also influence parasitism. Milkweeds occur in patches of various sizes and show a clumped dispersion pattern (Zalucki, 1980). It is generally accepted that the spatial dispersion of resources, their density and other aspects of environmental heterogeneity such as background vegetation, associated plants, barriers and size, can have significant effects on population colonisation and survival (e.g. Huffaker, 1958; Dethier, 1959; Pimentel *et al.*, 1963; Dempster, 1969; Root, 1973; Cromartie, 1975; Ralph, 1977).

Samples from small isolated patches as opposed to large patches show up to a two-fold difference in the percent parasitism. Given the wide range of patch sizes one might expect a wide variance in levels of parasitism. Only a much more extensive sampling programme encompassing the full spectrum of patch sizes could reveal the statistical relationship between percent parasitism and patch size.

In the only other study of parasitism in *D. plexippus* larvae in Australia Smithers (1973) recorded *Winthemia diversa* (Malloch) as the major tachinid parasitoid and a few specimens of *Sturmia* sp. The absence of *W. diversa* from my own larval collections suggests that perhaps the range of this tachinid does not extend into coastal south-east Queensland. It should be noted that Smithers' results are based on work in and around Sydney. On the other hand the temporal pattern of parasitism levels observed by J. Liddy in Queensland and reported by Smithers (1973) agree with my own observations presented in Fig. 1.

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